



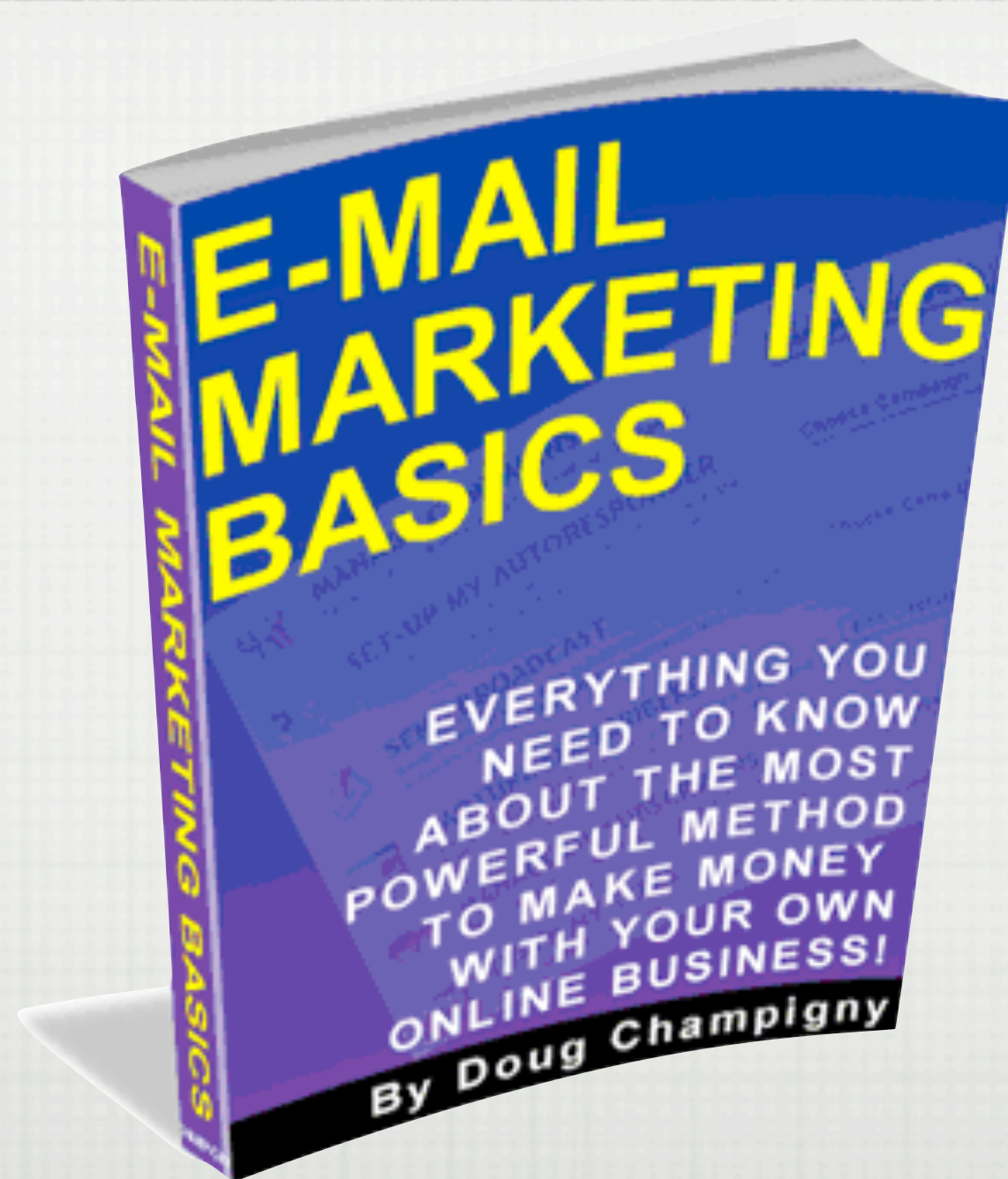
JOHDATUS TEKÖÄLYYN

TEEMU ROOS



HELSINGIN YLIOPISTO

KUINKA RIKASTUA



NAIVI BAYES

FROM: "MARGARETTA NITA" <MARGUERITesebrina@wmle.com>
SUBJECT: **SPECIAL OFFER : VIAGRA ON SALE AT \$1.38 !!!**
X-BOGOSITY: YES, **TESTS=BOGOFILTER, SPAMICITY=0.99993752,**
VERSION=2011-08-29
DATE: MON, 26 SEP 2011 21:52:26 +0300
X-CLASSIFICATION: **JUNK - AD HOC SPAM DETECTED (CODE = 73)**

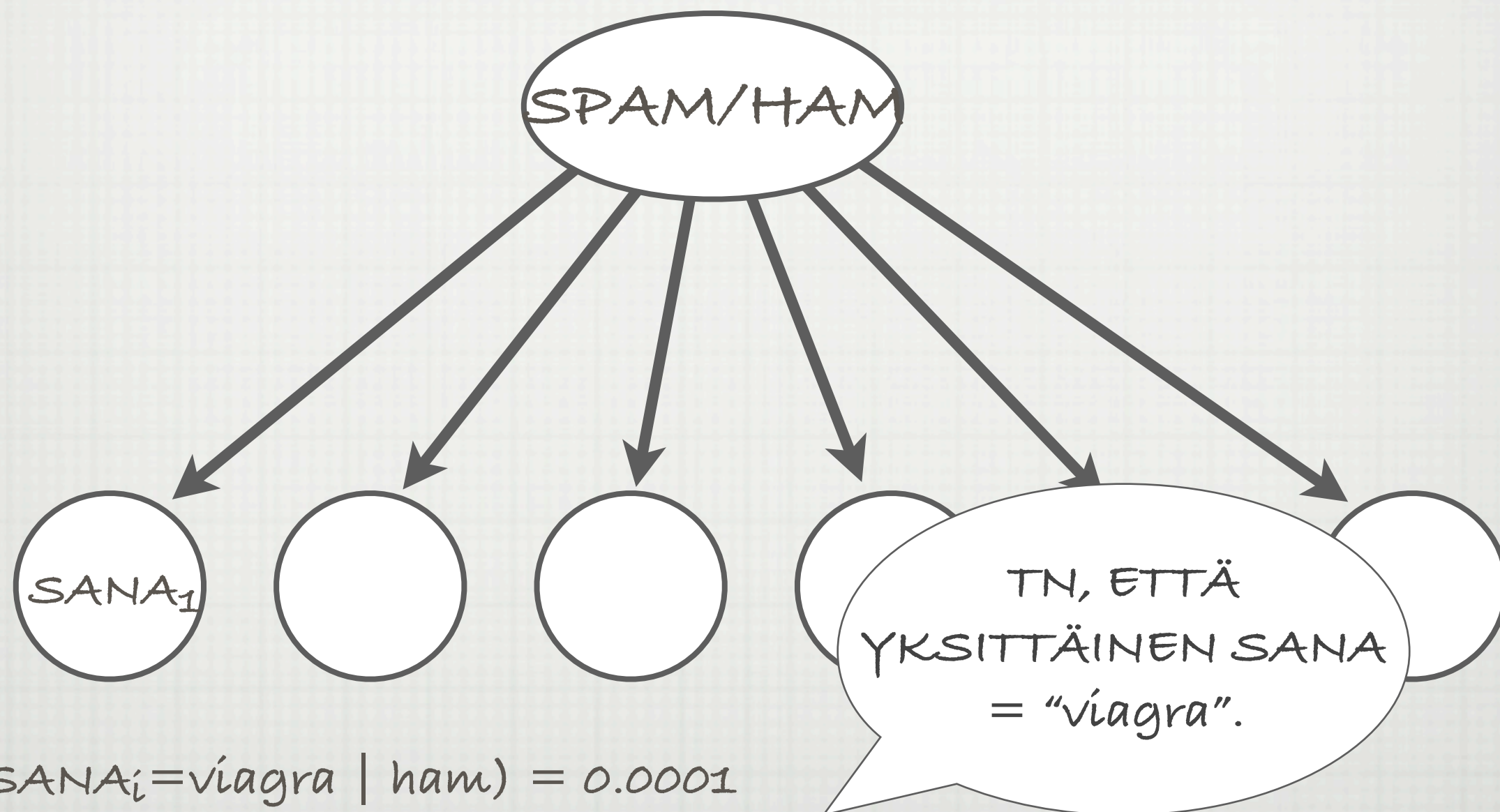
SPECIAL OFFER : VIAGRA ON SALE AT \$1.38 !!!

COMPARE THE BEST ONLINE PHARMACIES TO **BUY VIAGRA**. ORDER
VIAGRA ONLINE WITH HUGE **DISCOUNT**.

MULTIPLE BENEFITS INCLUDE **FREE** SHIPPING, REORDER **DISCOUNTS**,
BONUS PILLS

HTTP://RXPHARMACYCVS.RU

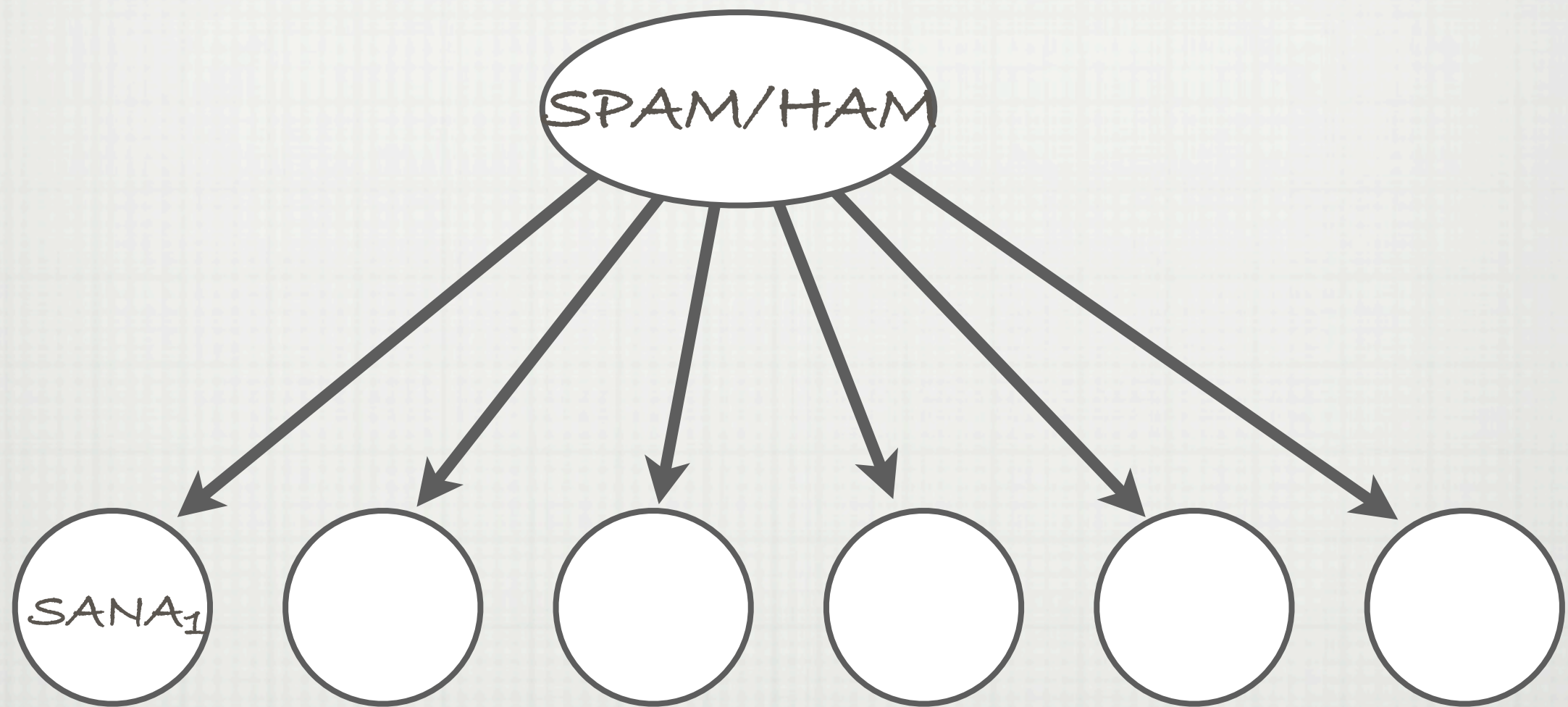
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$$P(SANA_i = víagra \mid ham) = 0.0001$$

$$P(SANA_i = víagra \mid spam) = 0.002$$

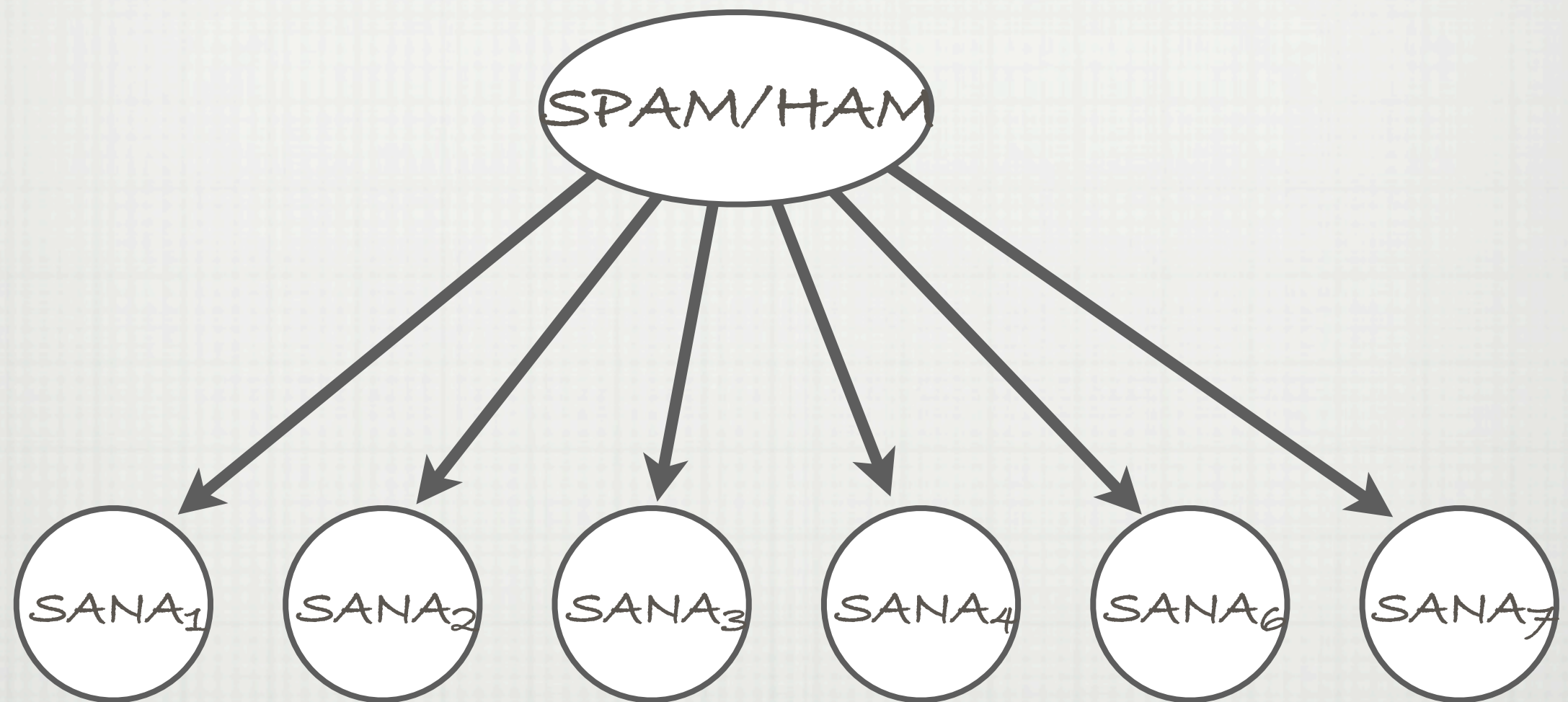
NAIVI BAYES



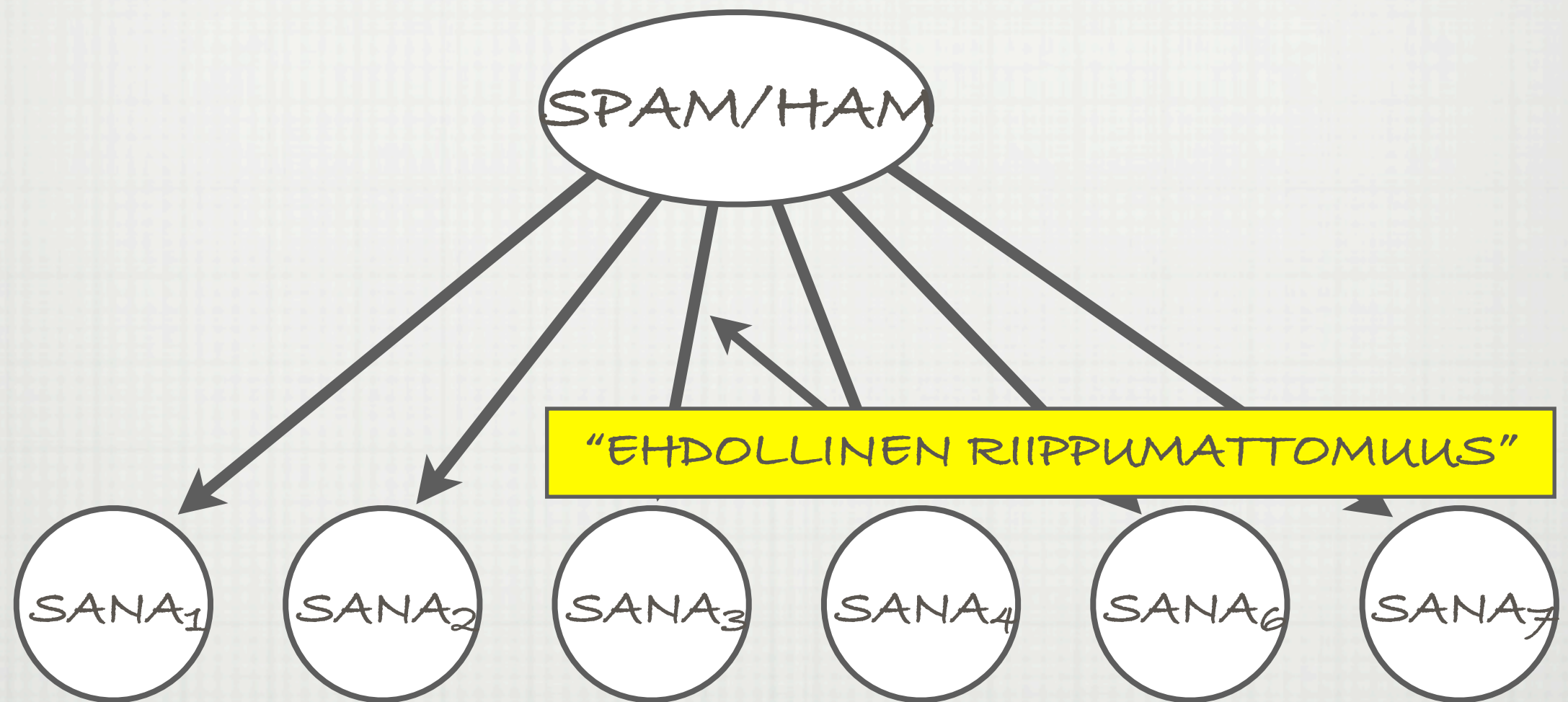
$$P(SANA_i = \$ \mid \text{ham}) = 0.0002$$

$$P(SANA_i = \$ \mid \text{spam}) = 0.005$$

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MUUTTUJAT:

1. LUOKKA: spam/ham
2. $SANA_1$
3. $SANA_2$
4. ...

JAKAUMAT:

$$P(SPAM=1) = 0.5$$

$$P(SANA_i=viagra | spam) = 0.002$$

$$P(SANA_i=viagra | ham) = 0.0001$$

$$P(SANA_i=\$ | spam) = 0.005$$

$$P(SANA_i=\$ | ham) = 0.0002$$

$$P(SANA_i=is | spam) = 0.002$$

$$P(SANA_i=is | ham) = 0.002$$

$$P(SANA_i=algorithm | spam) = 0.0001$$

$$P(SANA_i=algorithm | ham) = 0.002$$

JNE...



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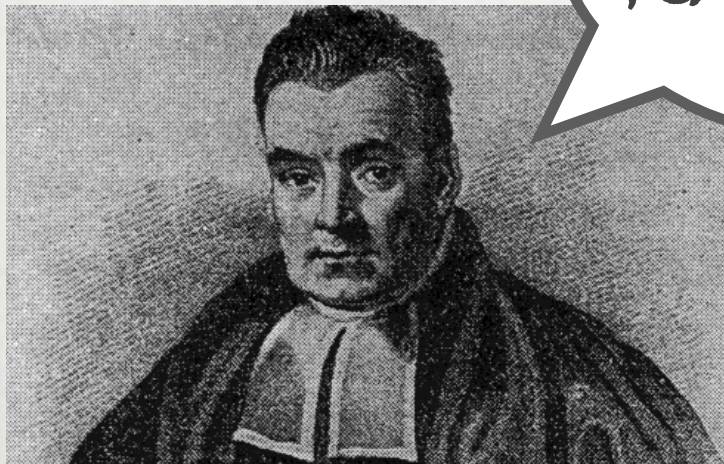
PÄÄTTELY:

1. $P(\text{spam}) = 0.5$

$P(\text{spam}) P(\text{SANA}_1 = \text{víagra} \mid \text{spam})$

2. $P(\text{spam} \mid \text{SANA}_1 = \text{víagra}) = \frac{\text{-----}}{P(\text{SANA}_1 = \text{víagra})}$

BAYESIN
KAAVA!



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PÄÄTTELY:

1. $P(\text{spam}) = 0.5$

$$P(\text{spam}) P(\text{SANA}_1 = \text{víagra} \mid \text{spam})$$

2. $P(\text{spam} \mid \text{SANA}_1 = \text{víagra}) = \frac{\text{-----}}{P(\text{SANA}_1 = \text{víagra})}$

$$P(\text{SANA}_1 = \text{víagra}) = P(\text{spam}) P(\text{SANA}_1 = \text{víagra} \mid \text{spam}) \\ + P(\text{ham}) P(\text{SANA}_1 = \text{víagra} \mid \text{ham})$$

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PÄÄTTELY:

1. $P(\text{spam}) = 0.5$

$$P(\text{spam}) P(\text{SANA}_1 = \text{víagra} \mid \text{spam})$$

2. $P(\text{spam} \mid \text{SANA}_1 = \text{víagra}) = \frac{P(\text{spam}) P(\text{SANA}_1 = \text{víagra} \mid \text{spam})}{P(\text{SANA}_1 = \text{víagra})}$

3. $P(\text{spam} \mid \text{SANA}_1 = \text{víagra}, \text{SANA}_2 = \text{ís})$

$$P(\text{spam}) P(\text{SANA}_1 = \text{víagra}, \text{SANA}_2 = \text{ís} \mid \text{spam})$$

$$= \frac{P(\text{spam}) P(\text{SANA}_1 = \text{víagra}, \text{SANA}_2 = \text{ís} \mid \text{spam})}{P(\text{SANA}_1 = \text{víagra}, \text{SANA}_2 = \text{ís})}$$

4. $P(\text{spam} \mid \text{SANA}_1 = \text{víagra}, \text{SANA}_2 = \text{ís}, \text{SANA}_3 = \text{algorithm})$

$$P(\text{spam}) P(\text{SANA}_1 = \text{víagra}, \text{SANA}_2 = \text{ís}, \text{SANA}_3 = \text{algorithm} \mid \text{spam})$$

$$= \frac{P(\text{spam}) P(\text{SANA}_1 = \text{víagra}, \text{SANA}_2 = \text{ís}, \text{SANA}_3 = \text{algorithm} \mid \text{spam})}{P(\text{SANA}_1 = \text{víagra}, \text{SANA}_2 = \text{ís}, \text{SANA}_3 = \text{algorithm})}$$

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PÄÄTTELY:

$$1. P(\text{spam}) = 0.5$$

$$P(\text{spam}) P(\text{SANA}_1 = \text{viagra} \mid \text{spam})$$

$$2. P(\text{spam} \mid \text{SANA}_1 = \text{viagra}) = \frac{P(\text{spam} \cap \text{SANA}_1 = \text{viagra})}{P(\text{SANA}_1 = \text{viagra})}$$

3. $P(\text{spam} \mid \text{SANA}_1 = \text{víagra}, \text{SANA}_2 = \text{ís})$

$$P(\text{spam}) P(\text{SANA}_1 = \text{viagra}, \text{SANA}_2 = \text{is} \mid \text{spam})$$

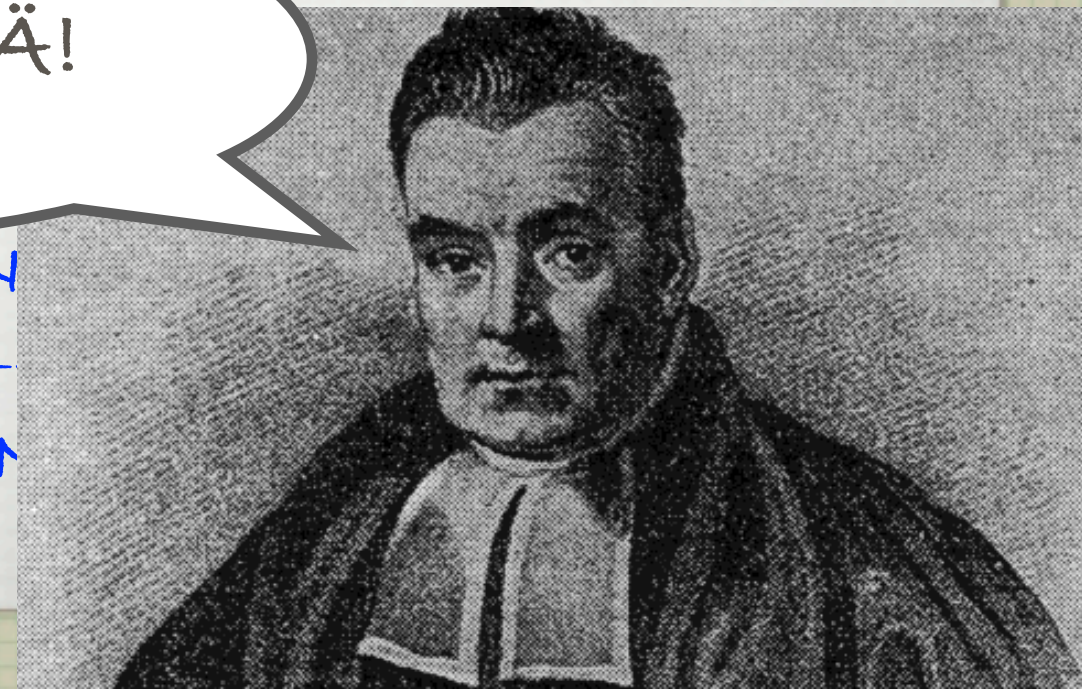
$P(SA)$

KAKSI NIKSIÄ!

4. $P(\text{spam} \mid \text{SANA}_1 = \text{very})$

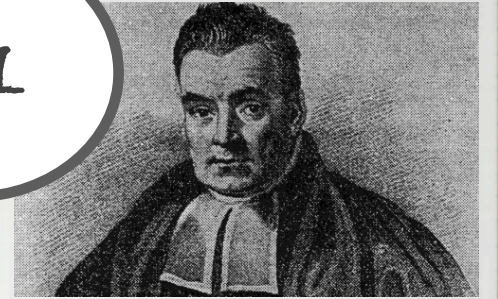
$$P(\text{spam}) P(\text{SANA}_1 = \text{viagra}, \text{SANA}_2 = \text{ls}, \text{SAN}$$

$$P(SANA_1 = \text{viagra}, SANA_2 = \text{is}, SAN$$



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#1



PÄÄTTELY:

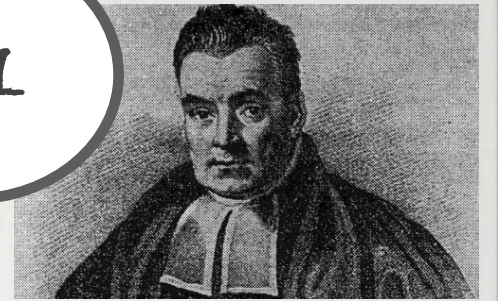
4. $P(\text{spam} \mid \text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

$P(\text{spam}) P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm} \mid \text{spam})$

$=$ -----
 $P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

NAIVI BAYES

#1



PÄÄTTELY:

4. $P(\text{spam} \mid \text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

$P(\text{spam}) P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm} \mid \text{spam})$

$=$ -----
 $P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

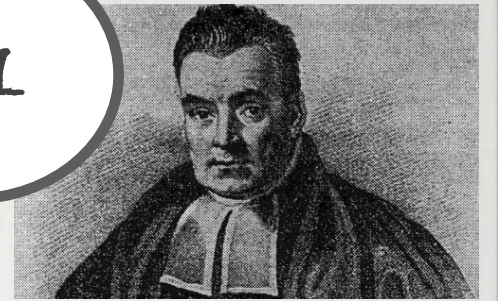
$P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

$= P(\text{spam}, \text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

$+ P(\text{ham}, \text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

NAIVI BAYES

#1



PÄÄTTELY:

4. $P(\text{spam} \mid \text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

$P(\text{spam}) P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm} \mid \text{spam})$

=
 $P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

$P(\text{evidenssi})$

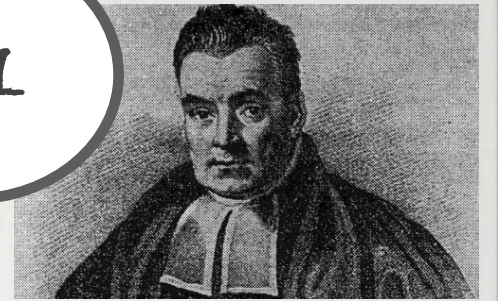
= $P(\text{spam}, \text{evidenssi})$

+ $P(\text{ham}, \text{evidenssi})$

// MARGINALISOINTI

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#1



PÄÄTTELY:

4. $P(\text{spam} \mid \text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

$P(\text{spam}) P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm} \mid \text{spam})$

=

$P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

$P(\text{evidenssi})$

$= P(\text{spam}, \text{evidenssi})$

$+ P(\text{ham}, \text{evidenssi})$

// MARGINALISOINTI

$P(\text{spam})P(\text{evidenssi} \mid \text{spam})$

$P(\text{spam} \mid \text{evidenssi}) =$

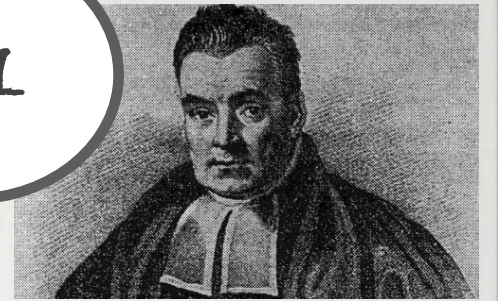
$\frac{P(\text{spam}, \text{evidenssi}) + P(\text{ham}, \text{evidenssi})}{P(\text{spam})P(\text{evidenssi} \mid \text{spam}) + P(\text{ham})P(\text{evidenssi} \mid \text{ham})}$

$P(\text{ham} \mid \text{evidenssi}) =$

$\frac{P(\text{spam}, \text{evidenssi}) + P(\text{ham}, \text{evidenssi})}{P(\text{spam})P(\text{evidenssi} \mid \text{spam}) + P(\text{ham})P(\text{evidenssi} \mid \text{ham})}$

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#1



PÄÄTTELY:

4. $P(\text{spam} \mid \text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

$P(\text{spam}) P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm} \mid \text{spam})$

$$= \frac{P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})}{P(\text{SANA}_1=\text{víagra} \mid \text{spam}) P(\text{SANA}_2=\text{ís} \mid \text{spam}) P(\text{SANA}_3=\text{algorithm} \mid \text{spam})}$$

$P(\text{evidenssi})$

$$= P(\text{spam}, \text{evidenssi}) + P(\text{ham}, \text{evidenssi})$$

// MARGINALISOINTI

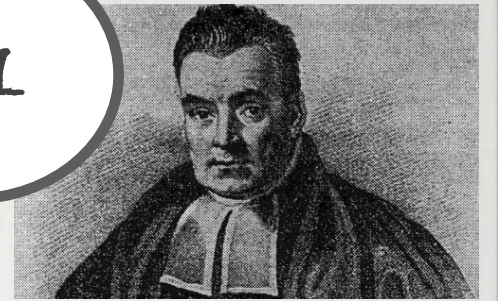
$$P(\text{spam}) P(\text{evidenssi} \mid \text{spam})$$

$$P(\text{spam} \mid \text{evidenssi}) = \frac{P(\text{spam}, \text{evidenssi})}{P(\text{spam}, \text{evidenssi}) + P(\text{ham}, \text{evidenssi})}$$

$$P(\text{ham} \mid \text{evidenssi}) = \frac{P(\text{ham}, \text{evidenssi})}{P(\text{spam}, \text{evidenssi}) + P(\text{ham}, \text{evidenssi})}$$

NAIVI BAYES

#1



PÄÄTTELY:

4. $P(\text{spam} \mid \text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

$P(\text{spam}) P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm} \mid \text{spam})$

$$= \frac{P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})}{P(\text{spam}) P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm} \mid \text{spam})}$$

$P(\text{evidenssi})$

$$= P(\text{spam}, \text{evidenssi}) + P(\text{ham}, \text{evidenssi})$$

// MARGINALISOINTI

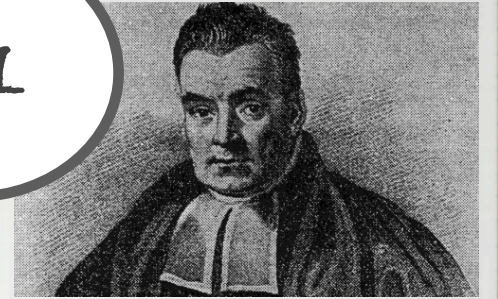
$$P(\text{spam}) P(\text{evidenssi} \mid \text{spam})$$

$$P(\text{spam} \mid \text{evidenssi}) = \frac{P(\text{spam}, \text{evidenssi})}{P(\text{spam}) P(\text{evidenssi} \mid \text{spam}) + P(\text{ham}, \text{evidenssi})}$$

$$P(\text{ham} \mid \text{evidenssi}) = \frac{P(\text{ham}, \text{evidenssi})}{P(\text{spam}, \text{evidenssi}) + P(\text{ham}, \text{evidenssi})}$$

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#1



PÄÄTTELY:

4. $P(\text{spam} \mid \text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

$P(\text{spam}) P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm} \mid \text{spam})$

$=$ -----
 $P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

$P(\text{evidenssi})$

$= P(\text{spam}, \text{evidenssi})$
 $+ P(\text{ham}, \text{evidenssi})$

// MARGINALISOINTI

$P(\text{spam} \mid \text{evidenssi})$

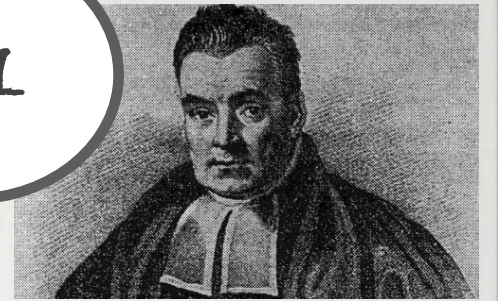
$P(\text{spam})P(\text{evidenssi} \mid \text{spam})$

 $P(\text{ham} \mid \text{evidenssi})$

$=$ -----
 $P(\text{ham})P(\text{evidenssi} \mid \text{ham})$

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#1



PÄÄTTELY:

4. $P(\text{spam} \mid \text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

$P(\text{spam}) P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm} \mid \text{spam})$

=

$P(\text{SANA}_1=\text{víagra}, \text{SANA}_2=\text{ís}, \text{SANA}_3=\text{algorithm})$

$P(\text{evidenssi})$

$= P(\text{spam}, \text{evidenssi})$

$+ P(\text{ham}, \text{evidenssi})$

// MARK

$P(S \mid E)$

$P(S)P(E \mid S)$

----- = -----

$P(\neg S \mid E)$

$P(\neg S)P(E \mid \neg S)$

$P(\text{spam} \mid \text{evidenssi})$

$P(\text{spam})P(\text{evidenssi} \mid \text{spam})$

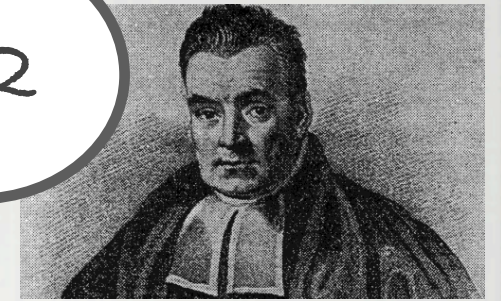
=

$P(\text{ham} \mid \text{evidenssi})$

$P(\text{ham})P(\text{evidenssi} \mid \text{ham})$

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#2



PÄÄTTELY:

$$P(SANA_1=viagra, SANA_2=is, SANA_3=algorithm | spam)$$

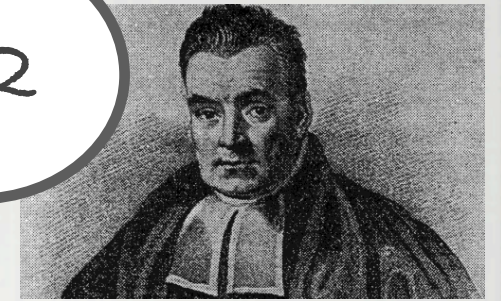
$$= P(SANA_1=viagra | spam) \quad // \text{KETJUSÄÄNTÖ}$$

$$P(SANA_2=is | SANA_1=viagra, spam)$$

$$P(SANA_3=algorithm | SANA_1=viagra, SANA_2=is, spam)$$

NAIVI BAYES

#2



PÄÄTTELY:

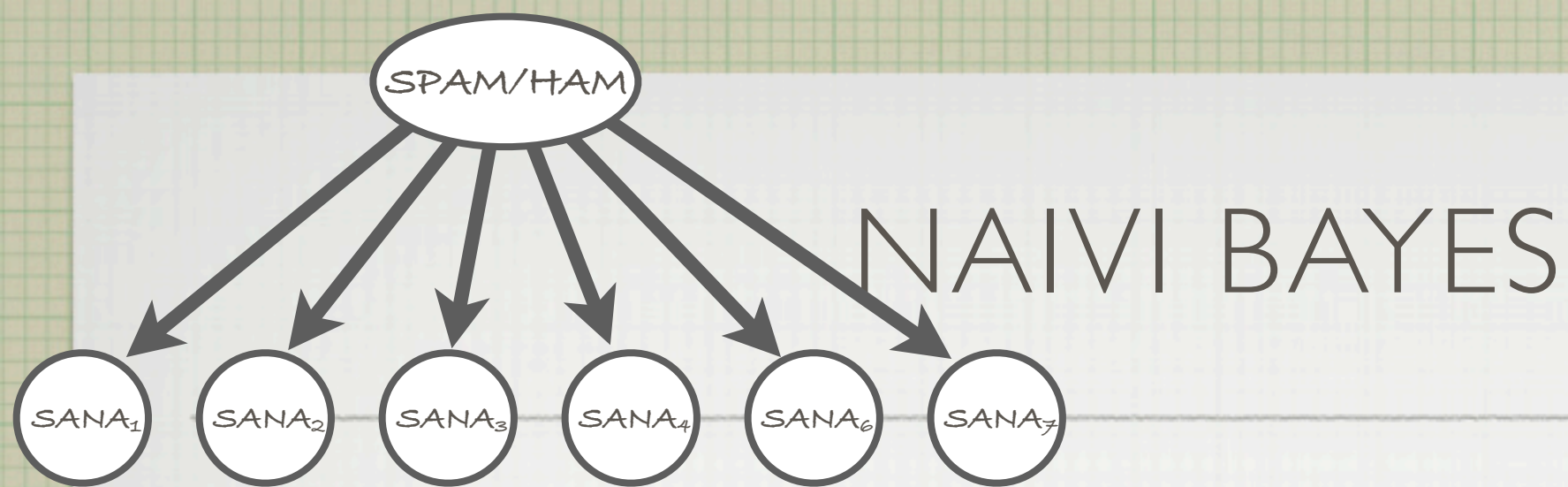
$$P(SANA_1=viagra, SANA_2=is, SANA_3=algorithm | spam)$$

$$= P(SANA_1=viagra | spam) \quad // \text{KETJUSÄÄNTÖ}$$

$$P(SANA_2=is | SANA_1=viagra, spam)$$

$$P(SANA_3=algorithm | SANA_1=viagra, SANA_2=is, spam)$$

// RIIPPUMATTOMUUS



#2



PÄÄTTELY:

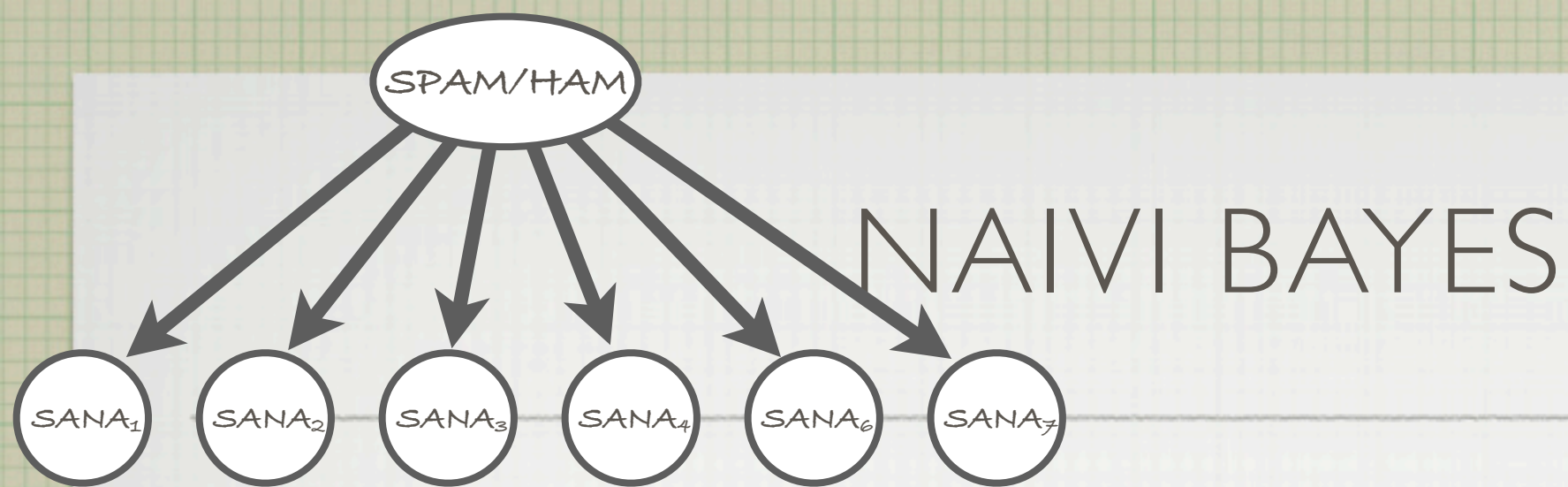
$$P(SANA_1=viagra, SANA_2=is, SANA_3=algorithm | spam)$$

$$= P(SANA_1=viagra | spam) \quad // \text{KETJUSÄÄNTÖ}$$

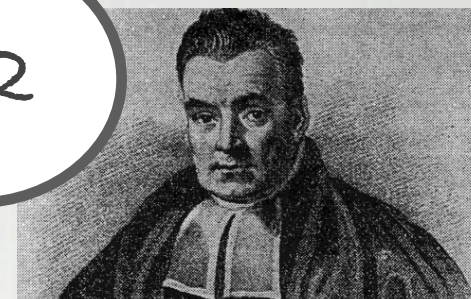
$$P(SANA_2=is | SANA_1=viagra, spam)$$

$$P(SANA_3=algorithm | SANA_1=viagra, SANA_2=is, spam)$$

// RIIPPUMATTOMUUS



#2



PÄÄTTELY:

$$P(SANA_1=viagra, SANA_2=is, SANA_3=algorithm | spam)$$

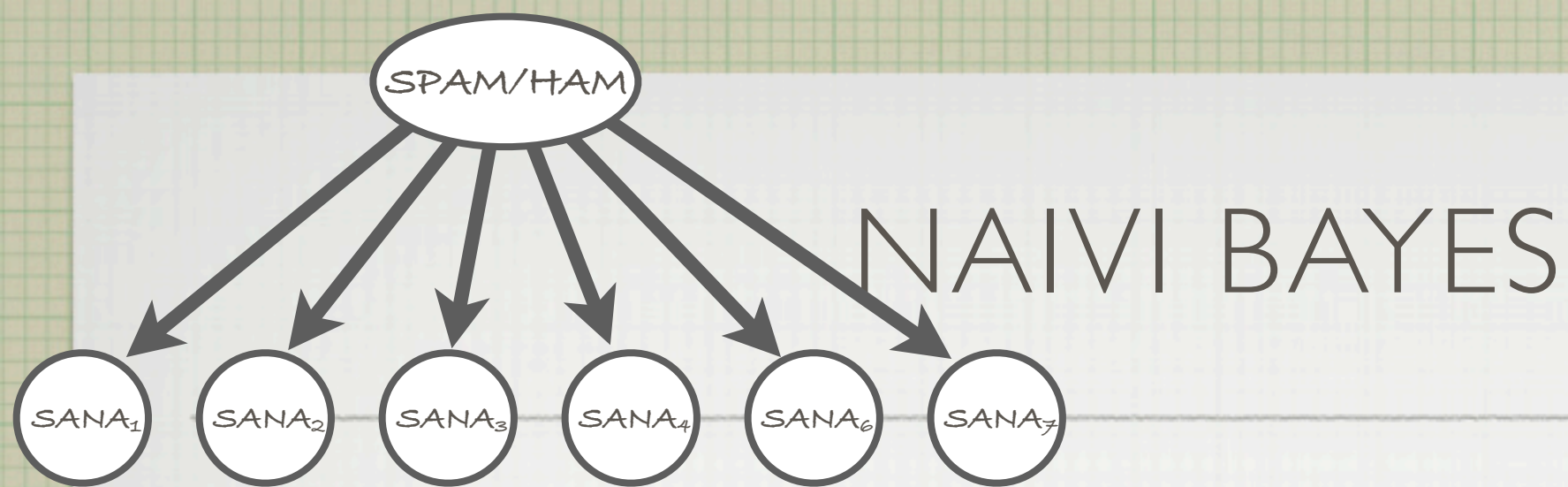
$$= P(SANA_1=viagra | spam)$$

// KETJUSÄÄNTÖ

$$P(SANA_2=is | \cancel{SANA_1=viagra}, spam)$$

$$P(SANA_3=algorithm | \cancel{SANA_1=viagra}, \cancel{SANA_2=is}, spam)$$

// RIIPPUMATTOMUUS



#2



PÄÄTTELY:

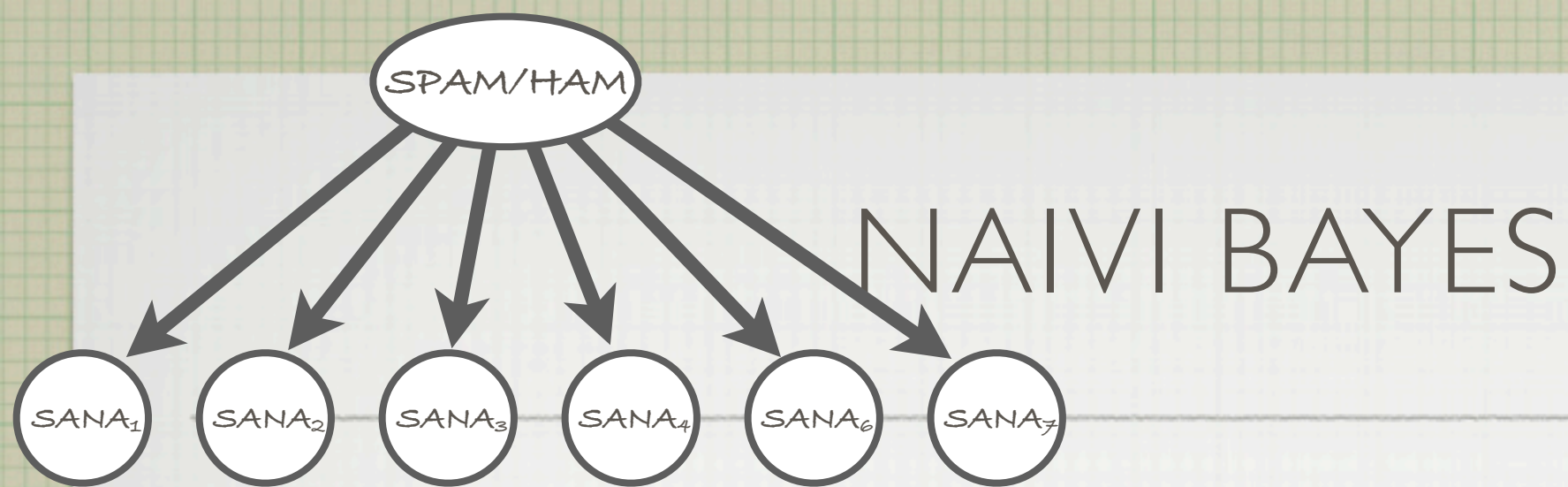
$$P(SANA_1=viagra, SANA_2=is, SANA_3=algorithm|spam)$$

$$= P(SANA_1=viagra|spam)$$

$$P(SANA_2=is|spam)$$

$$P(SANA_3=algorithm|spam)$$

// KETJUSÄÄNTÖ



#2



PÄÄTTELY:

$$P(SANA_1=viagra, SANA_2=is, SANA_3=algorithm | spam)$$

$$= P(SANA_1=viagra | spam)$$

$$P(SANA_2=is | spam)$$

$$P(SANA_3=algorithm | spam)$$

// KETJUSÄÄNTÖ

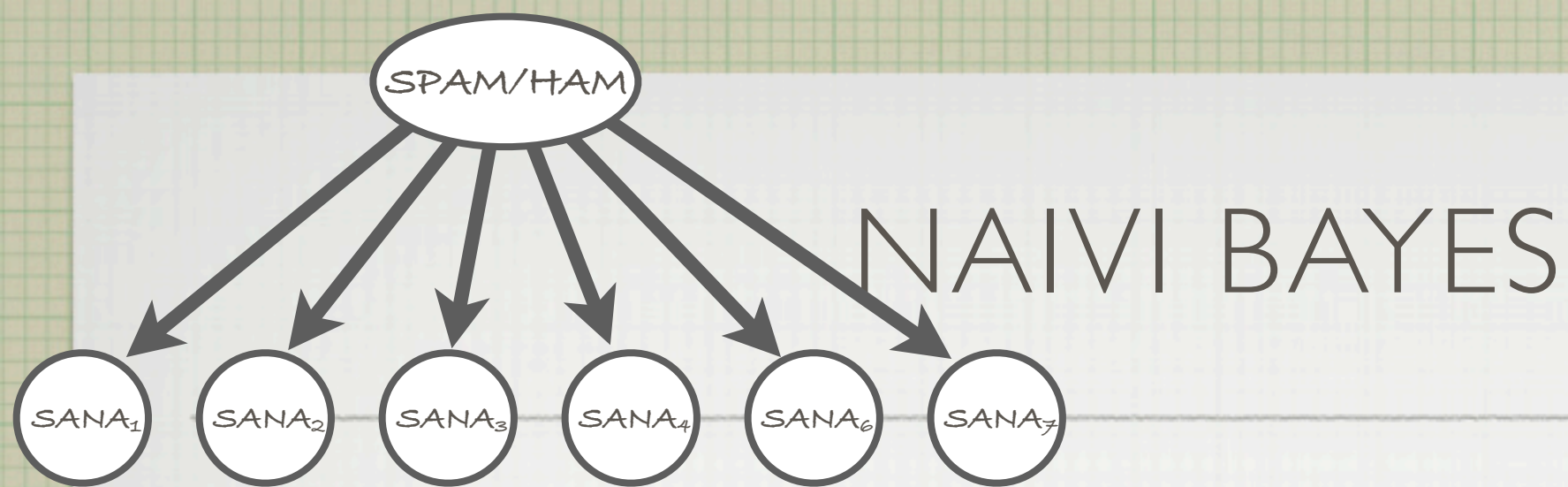
$$P(SANA_1=viagra, SANA_2=is, SANA_3=algorithm | ham)$$

$$= P(SANA_1=viagra | ham)$$

$$P(SANA_2=is | ham)$$

$$P(SANA_3=algorithm | ham)$$

// KETJUSÄÄNTÖ



#2



PÄÄTTELY:

$$P(SANA_1=viagra, SANA_2=is, SANA_3=algorithm|spam)$$

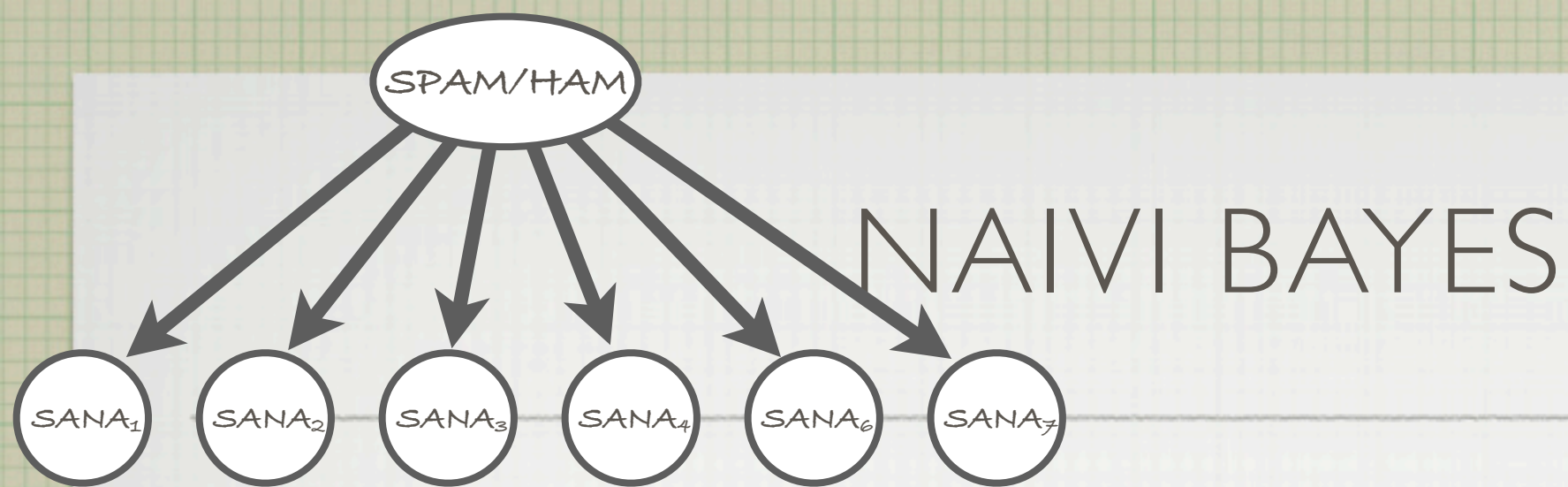
$$= P(SANA_1=viagra|spam) \\ P(SANA_2=is|spam) \\ P(SANA_3=algorithm|spam)$$

$$\frac{P(S|E) \quad P(S)P(E|S)}{P(\neg S|E) \quad P(\neg S)P(E|\neg S)}$$

$$P(SANA_1=viagra, SANA_2=is, SANA_3=algorithm|ham)$$

$$= P(SANA_1=viagra|ham) \\ P(SANA_2=is|ham) \\ P(SANA_3=algorithm|ham)$$

// KETJUSÄÄNTÖ



#2



PÄÄTTELY:

$$P(\text{spam} | \text{evidenssi}) / P(\text{ham} | \text{evidenssi})$$

$$= P(\text{spam}) / P(\text{ham})$$

$$P(SANA_1 = \text{viagra} | \text{spam}) / P(SANA_1 = \text{viagra} | \text{ham})$$

> 1

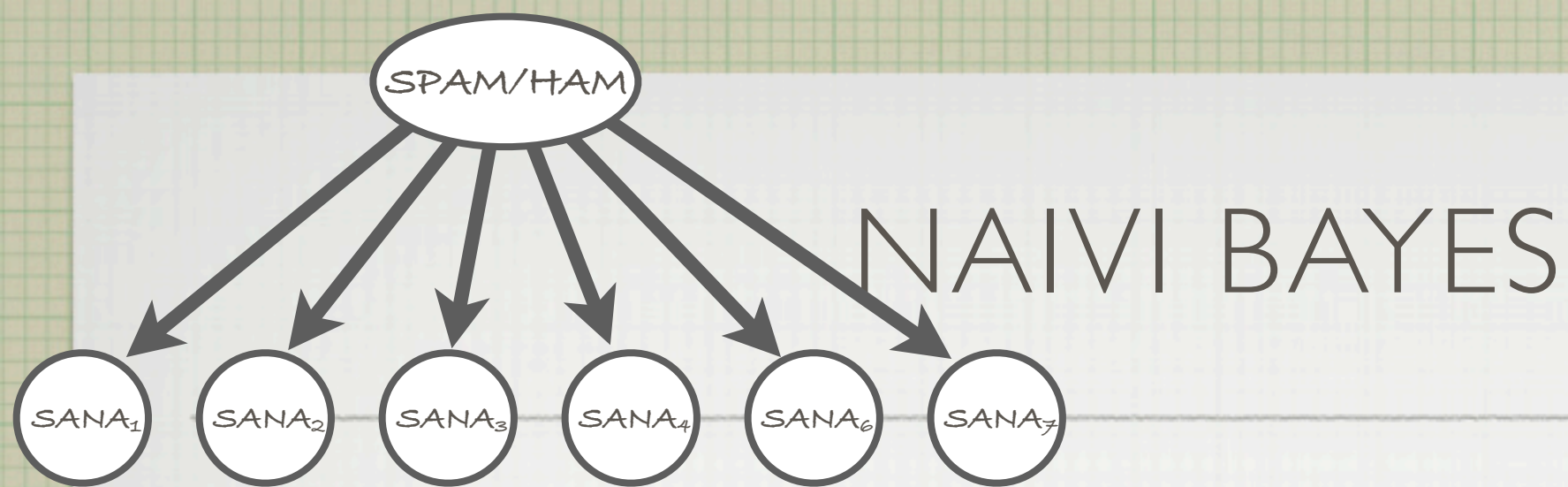
$$P(SANA_2 = \text{is} | \text{spam}) / P(SANA_2 = \text{is} | \text{ham})$$

$= 1$

$$P(SANA_3 = \text{algorithm} | \text{spam}) / P(SANA_3 = \text{algorithm} | \text{ham})$$

< 1

OSAMÄÄRÄ!



#2



PÄÄTTELY:

$$P(\text{spam} | \text{evidenssi}) / P(\text{ham} | \text{evidenssi})$$

$$= P(\text{spam}) / P(\text{ham})$$

$$P(\text{SANA}_1 = \text{viagra} | \text{spam}) / P(\text{SANA}_1 = \text{viagra} | \text{ham})$$

> 1

$$P(\text{SANA}_2 = \text{is} | \text{spam}) / P(\text{SANA}_2 = \text{is} | \text{ham})$$

= 1

$$P(\text{SANA}_3 = \text{algorithm} | \text{spam}) / P(\text{SANA}_3 = \text{algorithm} | \text{ham})$$

< 1

...

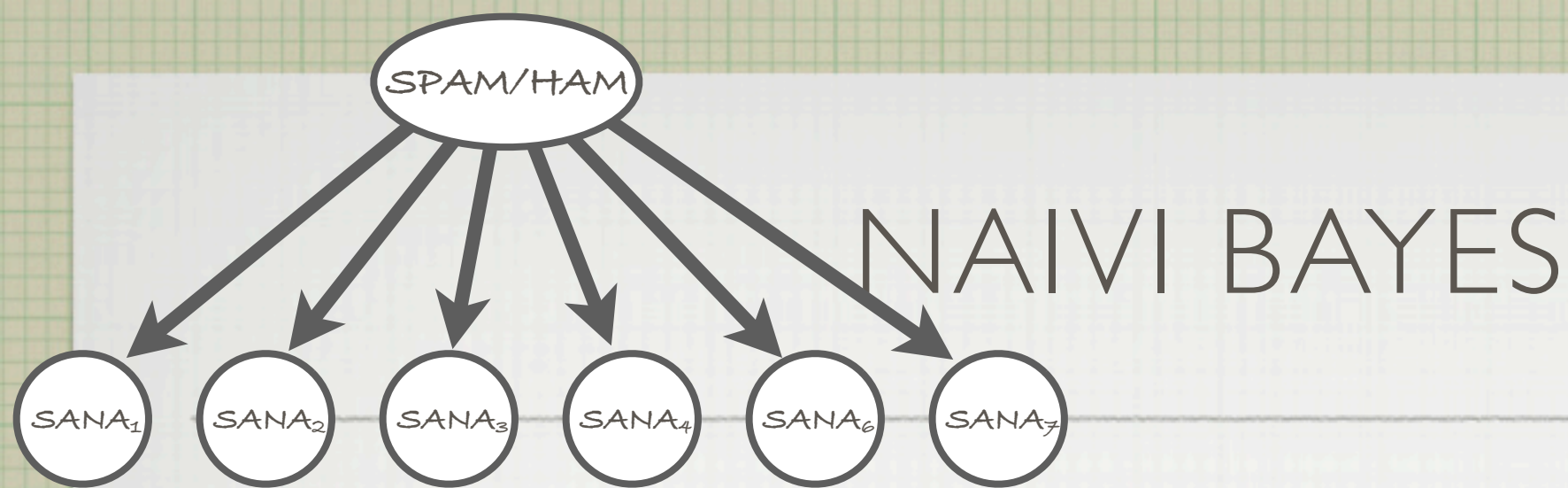
...

...

> 1 => LUOKITTELE: "SPAM"

< 1 => LUOKITTELE: "HAM"

OSAMÄÄRÄ!



PSEUDOKOODINA:

SPAMICITY(Viesti, P):

Odds = P.Spam / P.noSpam # P.Spam + P.noSpam = 1

for each Sana in Viesti

Odds = Odds * P.Sana_Spam(Sana) / P.Sana_noSpam(Sana)

return(Odds)

PÄÄTTELY:

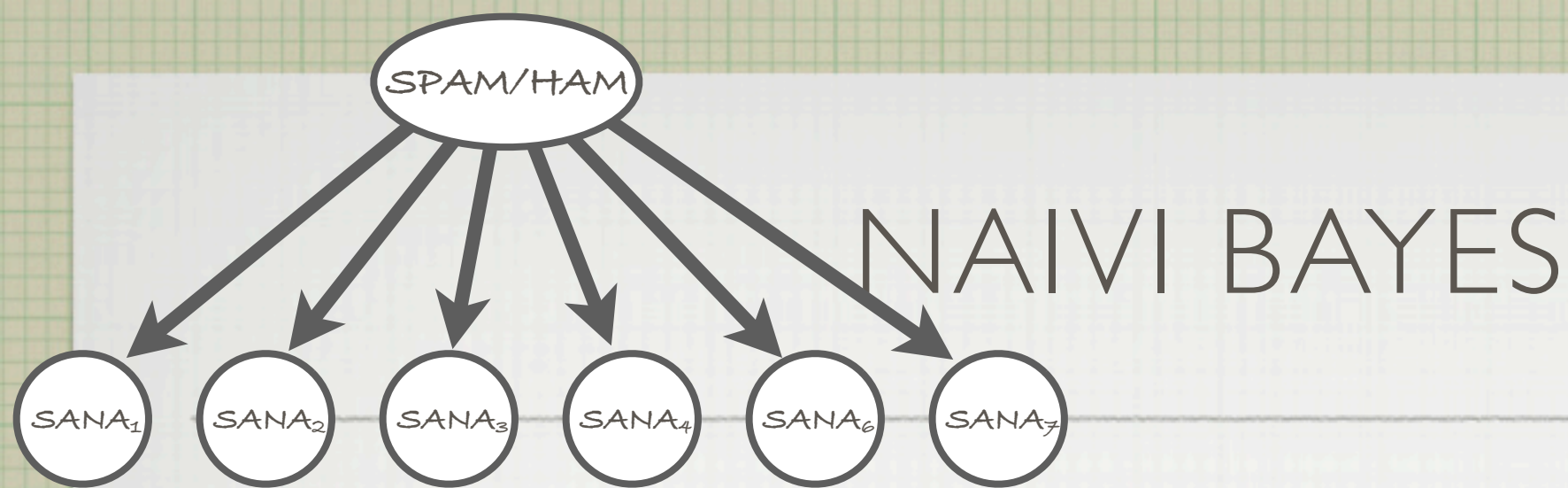
$$P(\text{spam} | \text{EVIDENSSI}) / P(\text{ham} | \text{EVIDENSSI})$$

$$= P(\text{spam}) / P(\text{ham})$$

$$P(\text{SANA}_1 = \text{viagra} | \text{spam}) / P(\text{SANA}_1 = \text{viagra} | \text{ham})$$

$$P(\text{SANA}_2 = \text{is} | \text{spam}) / P(\text{SANA}_2 = \text{is} | \text{ham})$$

$$P(\text{SANA}_3 = \text{algorithm} | \text{spam}) / P(\text{SANA}_3 = \text{algorithm} | \text{ham})$$



PSEUDOKOODINA:

SPAMICITY(Viesti, P):

Odds = P.Spam / P.noSpam # P.Spam + P.noSpam = 1

for each Sana in Viesti

Odds = Odds * P.Sana_Spam(Sana) / P.Sana_noSpam(Sana)

return(Odds)

PÄÄTTELY:

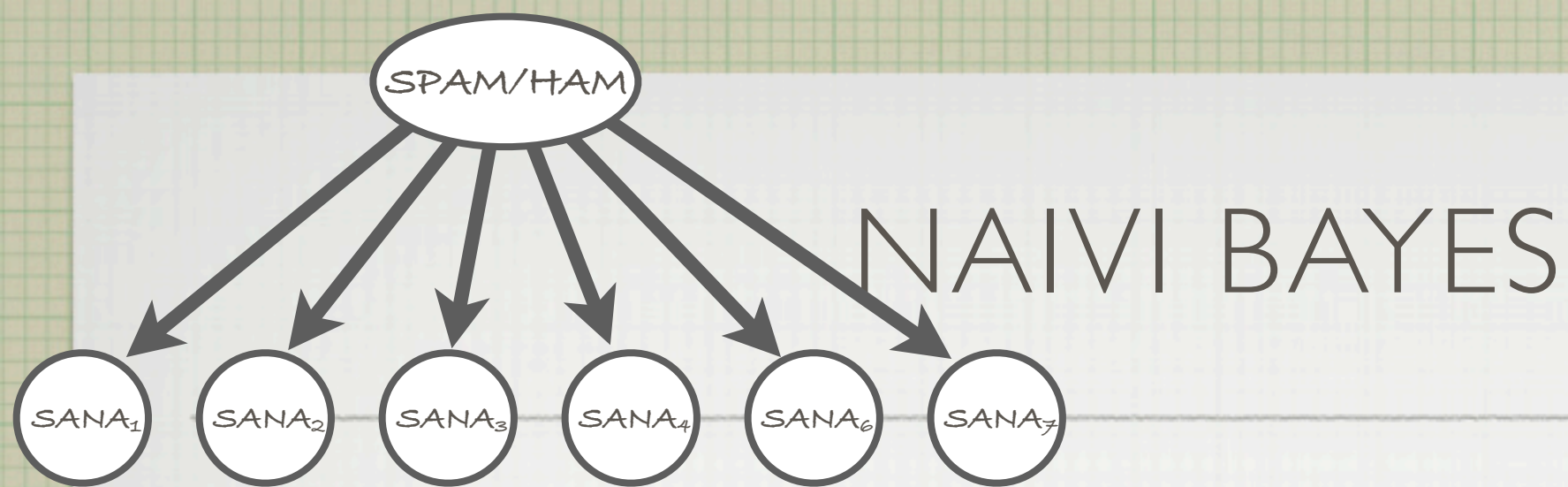
$P(\text{spam} | \text{EVIDENSSI}) / P(\text{ham} | \text{EVIDENSSI})$

$= P(\text{spam}) / P(\text{ham})$

$P(\text{SANA}_1 = \text{viagra} | \text{spam}) / P(\text{SANA}_1 = \text{viagra} | \text{ham})$

$P(\text{SANA}_2 = \text{is} | \text{spam}) / P(\text{SANA}_2 = \text{is} | \text{ham})$

$P(\text{SANA}_3 = \text{algorithm} | \text{spam}) / P(\text{SANA}_3 = \text{algorithm} | \text{ham})$



PSEUDOKOODINA:

SPAMICITY(Viesti, P):

Odds = P.Spam / P.noSpam # P.Spam + P.noSpam = 1

for each Sana in Viesti

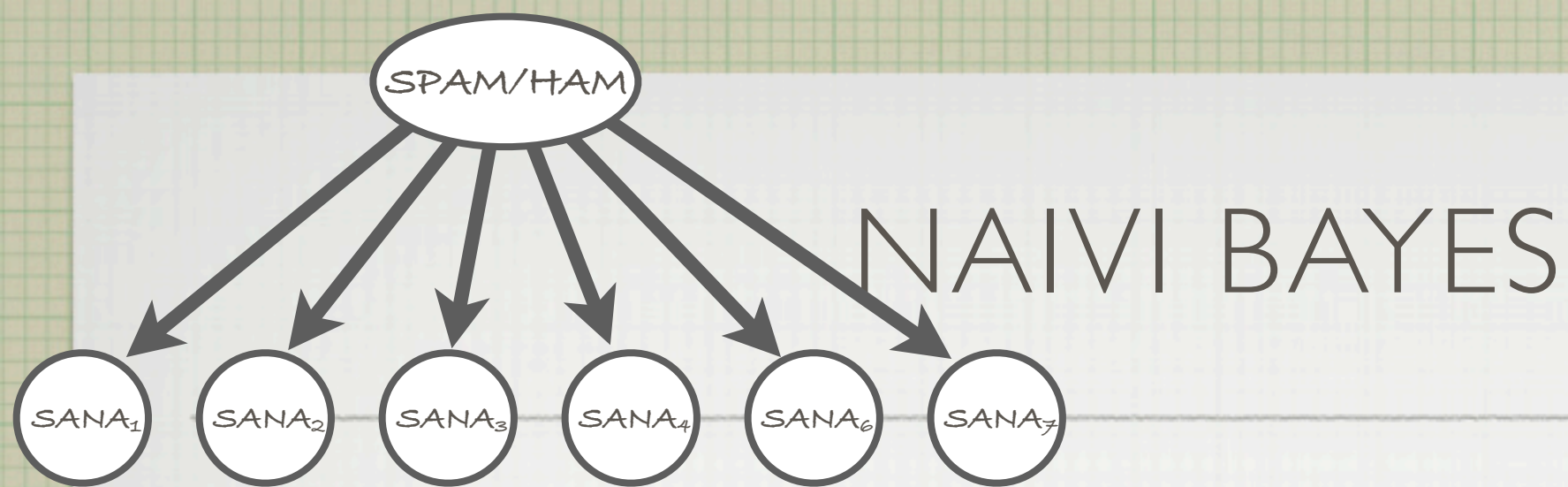
Odds = Odds * P.Sana_Spam(Sana) / P.Sana_noSpam(Sana)

return(Odds)

JOS SPAMICITY(Viesti, P) >1, LUOKITTELE VIEСТИ SPAMIKSI

JOS SPAMICITY(Viesti, P) <1, LUOKITTELE VIEСТИ HAMIKSI

JOS SPAMICITY(Viesti, P) =1, EN TIEDÄ



PSEUDOKOODINA:

SPAMICITY(Viesti, P):

Odds = P.Spam / P.noSpam # P.Spam + P.noSpam = 1

for each Sana in Viesti

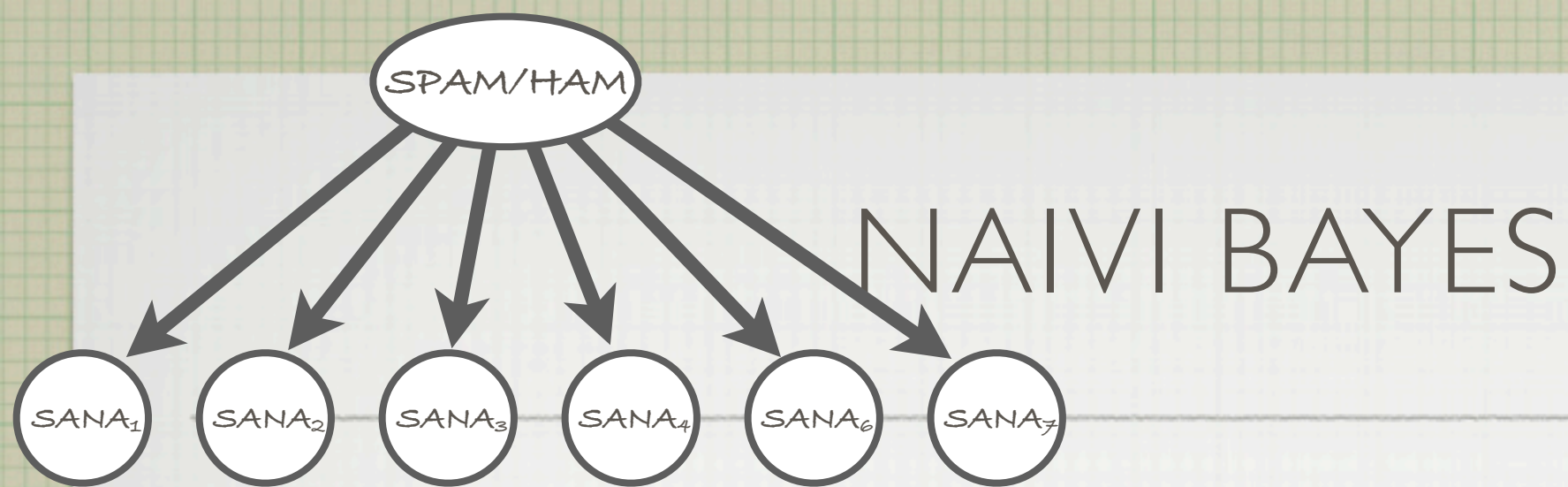
Odds = Odds * P.Sana_Spam(Sana) / P.Sana_noSpam(Sana)

return(Odds)

JOS SPAMICITY(Viesti, P) > $1 + \alpha$, LUOKITTELE VIEСТИ SPAMIKSI

JOS SPAMICITY(Viesti, P) < $1 - \beta$, LUOKITTELE VIEСТИ HAMIKSI

MUUTEN, EN TIEDÄ



PSEUDOKOODINA:

SPAMICITY(Viesti, P):

Odds = P.Spam / P.noSpam # P.Spam + P.noSpam = 1

for each Sana in Viesti

Odds = Odds * P.Sana_Spam(Sana) / P.Sana_noSpam(Sana)

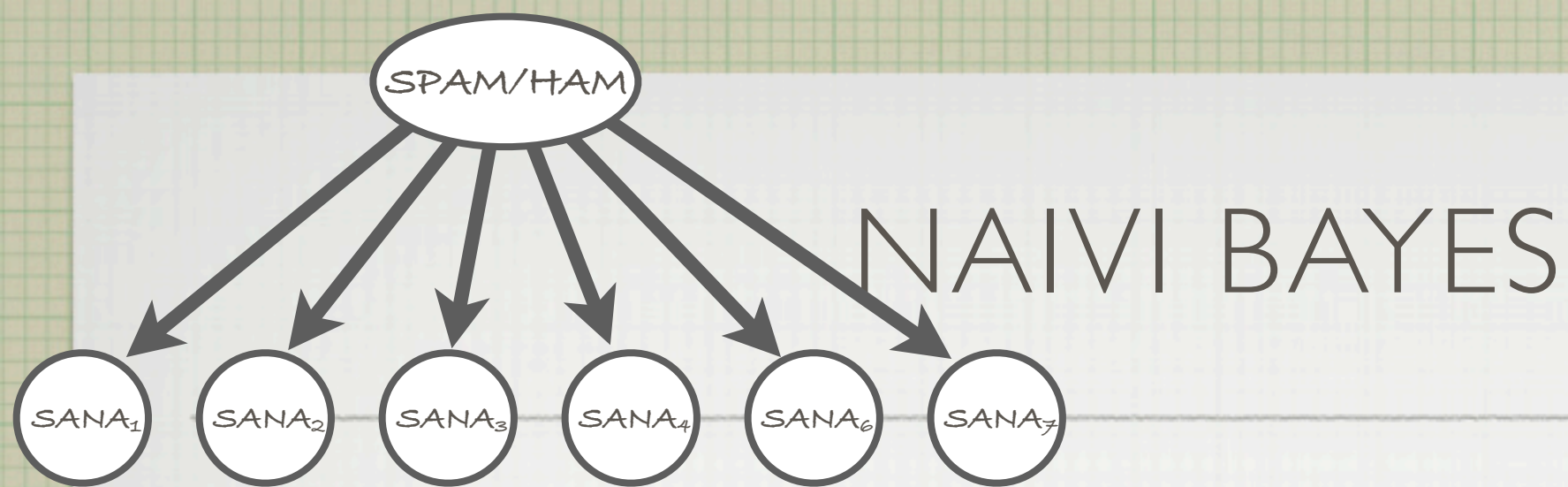
return(Odds)

JOS SPAMICITY(Viesti, P) > $1 + \alpha$, LUOKITTELE VIEСТИ SPAMIKSI

JOS SPAMICITY(Viesti, P) < $1 - \beta$, LUOKITTELE VIEСТИ HAMIKSI

MUUTEN, EN TIEDÄ

Epäsymmetrinen kustannusfunktio:
 ! Asiallisen viestin luokittelu spamiksi
 pahempi virhe kuin toisin päin



PSEUDOKOODINA:

$$\text{LOG}(A * B) = \text{LOG}(A) + \text{LOG}(B)$$

SPAMICITY(Viesti, P):

Odds = P.Spam / P.noSpam # P.Spam + P.noSpam = 1

for each Sana in Viesti

Odds = Odds * P.Sana_Spam(Sana) / P.Sana_noSpam(Sana)

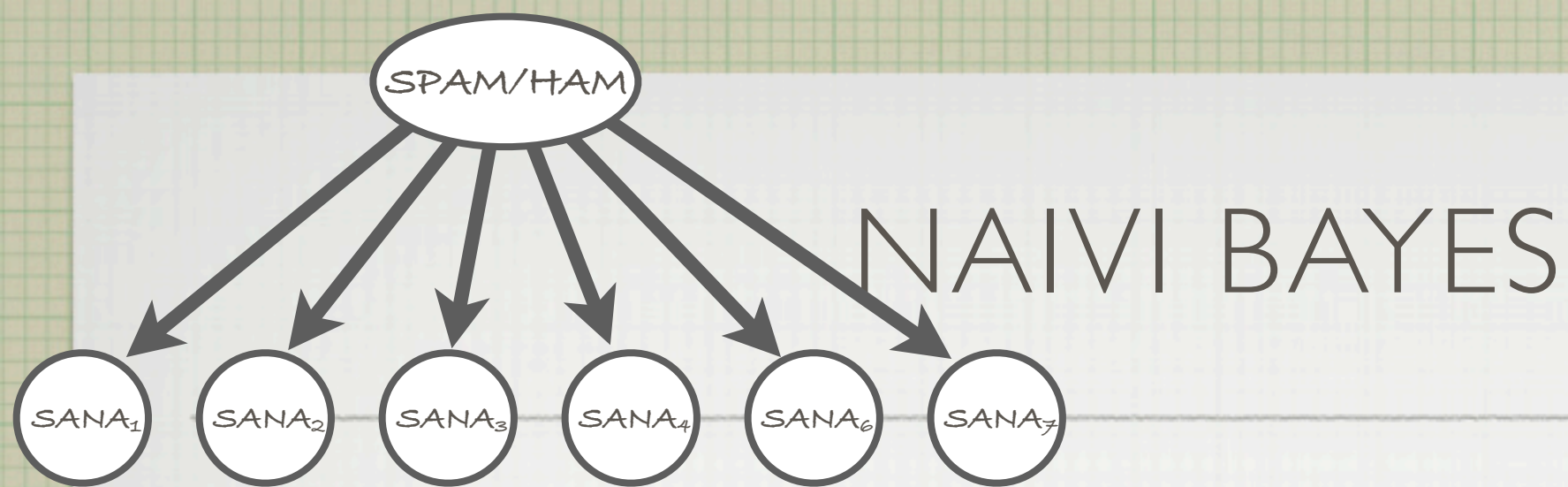
return(Odds)

KÄYTÄNNÖN ONGELMA: ALI-JA YLIVUODOT

Odds ARVOSTA TULEE HELPOSTI LIIAN PIENI (LÄHELLÄ NOLLAA)
TAI LIIAN SUURI.

RATKAISU:

KÄYTÄ $\log(\text{Odds})$



PSEUDOKOODINA:

$$\text{LOG}(A * B) = \text{LOG}(A) + \text{LOG}(B)$$

SPAMICITY(Viesti, P):

$\text{logOdds} = \text{log}(\text{P.Spam} / \text{P.noSpam})$ # $\text{P.Spam} + \text{P.noSpam} = 1$

for each Sana in Viesti

$\text{logOdds} = \text{logOdds} + \text{log}(\text{P.Sana_Spam}(\text{Sana}) / \text{P.Sana_noSpam}(\text{Sana}))$

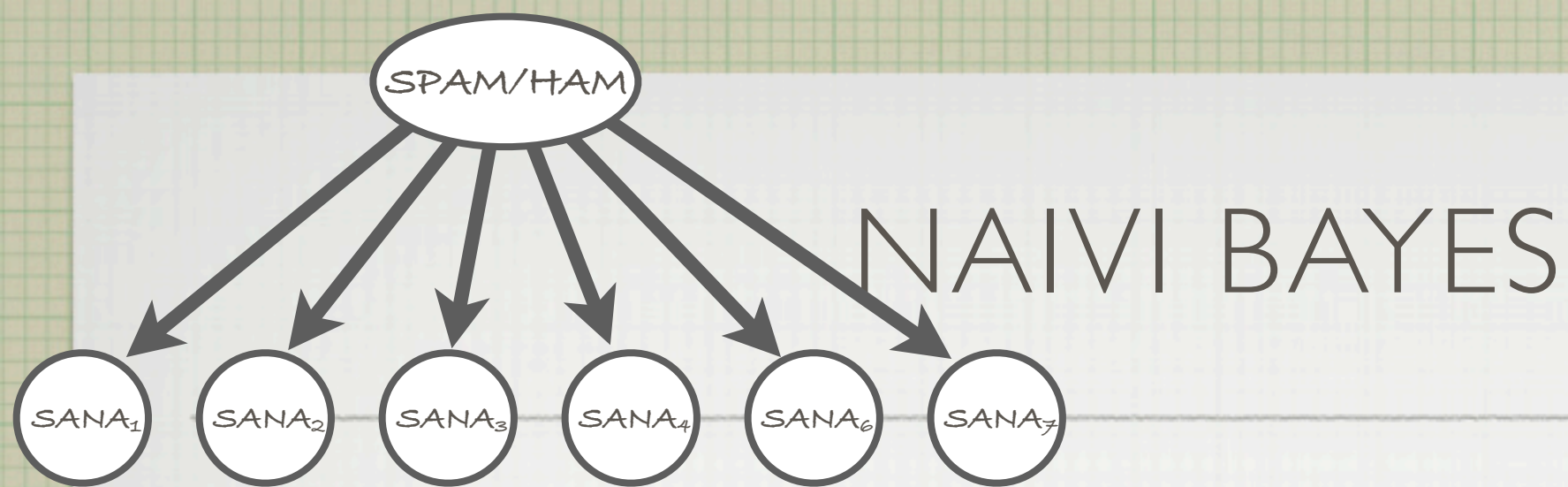
return($\text{exp}(\text{logOdds})$)

KÄYTÄNNÖN ONGELMA: ALI-JA YLIVUODOT

Odds ARVOSTA TULEE HELPOSTI LIIAN PIENI (LÄHELLÄ NOLLAA)
TAI LIIAN SUURI.

RATKAISU:

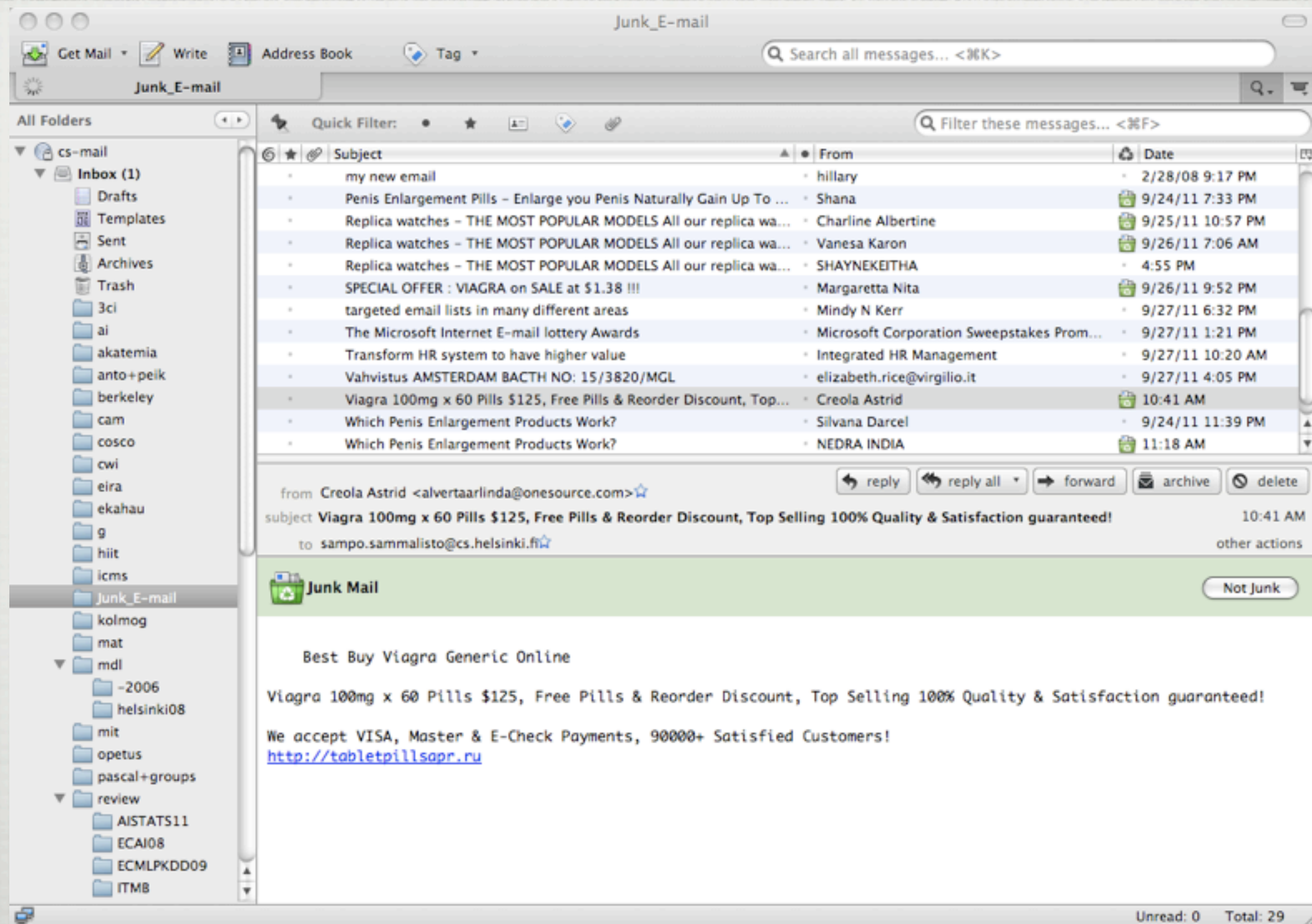
KÄYTÄ $\text{log}(\text{Odds})$



PARAMETRIEN OPPIMISESTA

- * VAIKEA KEKSIÄ PÄÄSTÄ EHDOLLISIA TN:IA.
- * HUONOT ARVOT HUONONTAVAT FILTTERIN TOIMINTAA
- * PAREMPI RATKAISU:
 1. KERÄÄ ISO KASA SPAM-VIESTEJÄ
 2. KERÄÄ ISO KASA HAM-VIESTEJÄ
 3. ARVIOI $P(SANA_i = \underline{\quad}) = 0.\underline{\quad}$ LASKEMALLA DATASTA
(VRT. LASKUHARJ. 3.3)
- * VAROTTAVA NOLLATODENNÄKÖISYYKSIÄ!
(JOS KASA EI TARPEEKSI ISO, JOTKUT SANAT EIVÄT VAIN SATU ESIINTYMÄÄN SIINÄ.)

ESIM.



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ESIM.

SPAM

1	MONEY	0.04	%
...			
5	VIAGRA	0.21	%
...			
10	IS	0.42	%
...			
19	REPLICA	0.80	%
20	EMAIL	0.84	%
20	YOU	0.84	%
21	DATABASE	0.88	%
25	EMAILS	1.05	%
26	OF	1.09	%
31	TO	1.30	%
43	AND	1.80	%
48	THE	2.01	%
TOTAL 2386			

HAM

21	ALGORITHM	0.01	%
...			
62	MONEY	0.02	%
...			
2199	FOR	0.78	%
2492	THAT	0.88	%
2990	YOU	1.05	%
3141	IN	1.11	%
3160	I	1.11	%
3218	AND	1.13	%
3283	IS	1.16	%
3472	OF	1.22	%
3874	A	1.37	%
5442	TO	1.92	%
9196	THE	3.24	%
TOTAL 283736			

ESIM.

SPAM

1	MONEY	0.04	%
...			
5	VIAGRA	0.21	%
...			
10	IS	0.42	%
...			
19	REPLICA	0.80	%
20	EMAIL	0.84	%
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3472	OF	1.22	%
3874	A	1.37	%
5442	TO	1.92	%
9196	THE	3.24	%
TOTAL 283736			

ESIM.

SPAM

1 MONEY 0.04 %

...

5 VIAGRA 0.21 %

...

10 I

...

19 R

20 E

20 Y

21 DATABASE 0.88 %

25 EMAILS 1.05 %

26 OF 1.09 %

31 TO 1.30 %

43 AND 1.80 %

48 THE 2.01 %

TOTAL 2386

HAM

21 ALGORITHM 0.01 %

...

62 MONEY 0.02 %

...

3218 AND 1.13 %

3283 IS 1.16 %

3472 OF 1.22 %

3874 A 1.37 %

5442 TO 1.92 %

9196 THE 3.24 %

TOTAL 283736

$$P(SANA_i = \text{MONEY} | \text{SPAM})$$

$$0.0004$$

$$P(SANA_i = \text{MONEY} | \neg \text{SPAM})$$

$$0.0002$$

$$\frac{0.0004}{0.0002} = 1.918 > 1$$

ESIM.

SPAM

1 MONEY 0.04 %

...

5 VIAGRA 0.21 %

...

10 I

$P(SANA_i = MONEY | SPAM)$

0.0004

...

19 R

----- = ----- = 1.918 > 1

20 E

$P(SANA_i = MONEY | \neg SPAM)$

0.0002

20 Y

21 DATABASE 0.88 %

25 E

$P(SANA_i = IS | SPAM)$

0.0042

26 O

31 T

----- = ----- = 0.3622 < 1

43 A

$P(SANA_i = IS | \neg SPAM)$

0.0116

48 T

TOTAL 2386

HAM

21 ALGORITHM 0.01 %

...

62 MONEY 0.02 %

...



3218 AND 1.13 %

TOTAL 283736

ESIM.

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...			
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9196	THE	3.24	%
TOTAL 283736			

YHTEENVETO

YHTEENVETO NAIVI BAYES-SPAMFILTTERISTÄ:

 TARVITAAN:

- "PRIORJAKAUMA" $P(\text{SPAM}) = 0.$ ___
- "LUOKKAEHDOLLISET" JAKAUMAT

$$P(SANA_i = VIAGRA | SPAM) = 0.$$

$$P(SANA_i = VIAGRA \mid \neg SPAM) = 0.$$

$$P(SANA_i = IS | SPAM) = 0.$$

$$P(SANA_i = IS \mid \neg SPAM) = 0.$$

$$P(\text{SANA}_i = \text{ALGORITHM} | \text{SPAM}) = 0.$$

$$P(\text{SANA}_i = \text{ALGORITHM} \mid \text{SPAM}) = 0. \quad P(\text{SANA}_i = \text{ALG.} \mid \neg \text{SPAM}) = 0.$$

- OLETETAAN ETTÄ $P(\text{SANA}_i | \text{SANA}_j, \text{SPAM}) = P(\text{SANA}_i | \text{SPAM})$
(EHDOLLINEN RIIPPUMATTOMUUS)

OLENNAISTA ON OSAMÄÄRÄ

$$P(SANA_i = VIAGRA | SPAM)$$

$$P(SANA_i = VIAGRA \mid \neg SPAM)$$

YHTEENVETO

(JATKOA...):

- * KUSTANNUSFUNKTIO **EPÄSYMMETRINEN**: PAREMPI SÄÄSTÄÄ MUUTAMA SPAM KUIN HUKATA OIKEA VIENTI (HAM)
- * JAKAUMAT PARAS **ESTIMOIDA** DATASTA
- * **NOLLATODENNÄKÖISYYKSILLE** TEHTÄVÄJOTAIN